**C 42054** **(Pages : 2)** **Name.....**

**Reg. No.....**

**FOURTH SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2023**

(CBCSS)

Physics

PHY 4E 14—LASER SYSTEMS, OPTICAL FIBRES AND APPLICATIONS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

**Section A**

8 *Short questions answerable within* 7.5 *minutes.*
*Answer* **all** *questions, each question carries weightage* 1.

1. Derive the rate equation for a four level laser system
2. Discuss briefly what unstable resonators are.
3. What is a line shape function ? What will be the total number of stimulated emissions per unit time per unit volume in terms of line shape function ?
4. Briefly explain the working principle of optical parametric oscillator.
5. What are single mode optical fibres ? What are the advantages and disadvantages of single mode fibres over multimode ones ?
6. Explain Z scan technique.
7. Briefly explain the mechanism in which a step index cylindrical optical fibre can act as a waveguide. Give the equation of motion and mention the different modes.
8. Explain any *two* applications of spatial frequency filter.

(8 × 1 = 8 weightage)

**Section B**

4 *essay questions, each answerable within* 30 *minutes.*
*Answer any* **two** *questions, each question carries weightage* 5.

9. Explain any *three* line broadening mechanisms in a laser system.
10. Discuss the theory of Q- switching and how it generates high power pulses.

**Turn over**

11. Explain the working principle of a semiconductor laser and a fiber laser semiconductor laser.

12. Explain the application of lasers in material processing and isotope separation.

(2 × 5 = 10 weightage)

## Section C

*7 problem questions, each answerable within 15 minutes*
*Answer any* **four** *questions, each question carries weightage 3.*

13. Derive Einstein's co-efficients in a laser. A He-Ne laser operating at 632.8 nm has an output power of 1.0 mW with a 1 mm beam diameter. Power in the cavity is 99 P since the output mirror has 1 % transmission. The beam diameter is also 1 mm inside the laser cavity and the power is uniform over the beam cross section. The laser linewidth is $1.5 \times 10^8$ Hz.

14. For a ruby laser of 6328 A° wavelength, the spontaneous emission co-efficient is $10^7$ $s^{-1}$. The active medium of length 20 cm and refractive index of 1.76 is installed in a two-mirror cavity having mirror reflectivities of 99.9 % and 98 %. Calculate the time in which energy in the cavity is reduced by a factor of 1/e. Also find the threshold population inversion. Given the normalised line shape function as $1.6 \times 10^{-10}$ s. Assume no losses in the cavity other than the mirror transmission losses.

15. Derive the criteria for a stable laser cavity.

16. Compute the Doppler broadening for the 632.8-nm laser transition in the He-Ne laser, assuming a single isotope of $Ne^{20}$ and that the laser operates at a discharge bore temperature of 100°C.

17. Compare $CO_2$ laser with He-Ne laser with respect to the energy level diagram, frequency of emission, pumping and efficiency.

18. Compare step index and graded index optical fibre. Calculate the number of modes for a graded index optical fiber if its core diameter d = 62.5 μm, refractive index of core and cladding are 1.48 and 1.46 and its operating wavelength = 1433 nm.

19. The core diameter of a single mode optical fiber is 10 μm. the fiber is coupled to semiconductor laser rated to operate at 1.3 μm. The refractive index of the core glass material is 1.55. The maximum numerical aperture is 0.995. Calculate the refractive index of the cladding. Show that all the rays making an angle < 5.712° with the axis of fiber will be guided through it.

(4 × 3 = 12 weightage)